METHODS FOR CONTROLLING
CROP DAMAGE BY
BIG GAME

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INTRODUCTION

Big game damage to agricultural crops and forest lands has been a problem for many years. Depredation by pronghorn antelope (Antiloropira americana), and by white-tailed (Odocoileus virginianus) and mule deer (O. hemiones) as well as other cervids has occurred by foraging on agricultural crops (Craven 1980, 1983, Daniel 1962, Halls 1978, Korschgen 1962, McDowell and Pillsbury 1959, Palmer et al. 1982. Roberts 1964, Schemnitz 1983, Webb 1960, Wilkins 1957) or browsing in forests (Aimonetti 1977, Daniel 1962, Roberts 1964, Webb 1960). However, big game species also have economic value through hunter expenditures on license fees, transportation, food, lodging, and equipment, as well as aesthetic value. These species must therefore be managed to satisfy a variety of interest groups. These groups' needs in Montana can be served by a combination of population control through hunting, a conscientious effort at damage control by landowners, and a state program to assist landowners.

The control of big game depredation to man's resources is a problem for which there is no simple solution. The following literature review of techniques for prevention of big game agricultural crop depredation is a preliminary step towards developing a management plan to control this depredation.

METHODS

Information for this review was obtained previously from literature searches at the Montana State University library. Additional literature was provided by Richard Mackie and John Weigand. Some information from the Wildlife Division library was used as was literature from a computer search by Fish and Wildlife Reference Service, Rockville, MD. Interviews with department wildlife field biologists provided additional information. Reviews of this information were compiled to comprise this report and to provide recommendations for prevention of big game agricultural crop depredation in southeastern Montana.

RESULTS AND DISCUSSION

Big game damage control techniques, both in the United States and in Europe, fall into the following categories: 1) population control, 2) exclusion, 3) cultural methods, 4) repellents, 5) attractants, 6) removal, or 7) compensation.

Population Control

Effective use of the legal big game hunting seasons are the best way to control populations. It is a waste to kill big game under a special damage control permit when many eager hunters would do it and make use of the resource. Landowners who permit hunting give the public access to a public resource and help to solve their own damage problems. Hunting to control populations is therefore the primary method and most effective means of controlling crop damage (Craven 1980, Halls 1978,

Korschegen 1962, McDowell and Pillsbury 1959, Roseberry et al. 1969, Roberts 1964). In optimizing deer populations, managers need to consider public perception of the carrying capacity as well as the actual (Brown and Decker 1979, Craven 1980). Brown and Decker (1979) state that management is often based on farmer's complaints which aren't always representative, but are the only public concern voiced. They reported that a method integrating farmer attitudes into deer population management derived by analyzing the relationship of results of questionnaires to indices of deer population densities was better than nonsystematic monitoring of farmer attitudes by assessing damage complaint levels. If the carrying capacity index they derived was met or exceeded, antlerless deer hunting would be allowed the following season. McDowell and Pillsbury (1959) indicated that manipulation of seasons and bag limits was considered by all states as one measure of controlling game damage. Daniel (1962) reported that 3 species of deer causing damage were controlled by hunting in New Zealand.

Special pre- or post-season hunts or kill permits are additional methods of controlling damage. Marcoux (1983) reported pre- and post-season depredation hunts have been used as a control measure in most Montana game management regions. Roseberry et al. (1969) and Roseberry and Klimstra (1974) reported as successful a controlled deer hunt in January on a National Wildlife Refuge in Illinois, although there was a differential take between sex and age. Probably the most widely used method of altering hunting regulations to control damage is allowing antlerless or any deer seasons (Brown and Decker 1979, Korschgen 1962, Marcoux 1983, McDowell and Pillsbury 1959, Roberts 1964). Where no other means of game damage prevention are adequate the Montana Department of Fish, Wildlife, and Parks (MDFWP) may issue special kill permits to landowners or dispatch animals themselves as do other states (Craven 1980, Longhurst et al. 1962, Roberts 1964).

Matschke (1977, 1980) reported on the use of contraceptives for populations control but concluded that the method might only be useful for confined populations and that for free ranging population costs involved made the technique unfeasible. Poisoning has also been used in New Zealand (Daniel 1962) but public sentiment in this country would not allow use of this measure, especially considering the waste.

Exclusion

Exclusion of big game from agricultural crops by several means of temporary or permanent fencing is probably the most effective means of preventing crop damage but also the most expensive (Brenneman 1982; Caslick and Decker 1979; Craven 1983, 1980; George et al. 1983; Halls et al. 1965; Jones and Longhurst 1958; Longhurst et al. 1962; McDowell and Pillsbury 1959; Porter 1983; Roberts 1964; Schemnitz 1983; Tierson 1969; Webb 1960). Of these, construction of woven wire fencing is the most effective

and expensive. For deer these fences must be at least 8 ft. (2.5 m) above ground as they can jump 6-8 ft., posts should be 10-12 ft. long, 10-12 ft. apart, and the mesh 2 x 4 in. to 6 x 8 in. (Craven 1983,1980; Halls et al. 1965; Jones and Longhurst 1958; Longhurst et al. 1962). For antelope a fence 4 ft. tall may be adequate (Schemnitz 1983). As pronghorn are very prone to mortality from entanglement in fences (Kitchen and O'Gara 1982, Yoakum 1978) a woven wire fence may be the only practical fence construction for preventing damage by antelope. Falk et al. (1978) found that highway right-of-way fencing 226 cm tall with a 13 cm gap at the bottom was inadequate as a deterrent to deer because the gap was too large and the fence not tall enough. Therefore, care should be used in fence construction.

Costs of this tall woven wire fencing was $2/linear ft. in 1978 but the fence life is approximately 20 years (Craven 1980). The cost for 5.2 mi. in 1964 was $16,429 (Halls et al. 1965). Jones and Longhurst (1958) reported a cost of $2500/mi. Caslick and Decker (1979) showed the savings from deer proof fencing to protect apple orchards (Table 1).

Table 1. Savings from using deer-proof fencing to protect a 20.23-ha (50 acre) orchard with a 1,829-m (6,000-ft) perimeter, at different planting densities, using a damage estimate of 50 cents/tree (Caslick and Decker 1979).

Trees/ha	Potential annual damage at 50 cents/tree $	Annual cost of deer-proof fence[a] $	Potential annual savings $
299	3,025	2,024	1,001
539	5,450	2,024	3,426
1,122	11,350	2,024	9,326
1,957	19,800	2,024	17,776

[a]This value was computed using a method derived from Conneman (1978), Hoglund (1976), and Knoblauch et al. (1978):

depreciation = $9,800 - 10 years (estimated fence life)	= $ 980
interest = 10% on average value of $4,900	= 490
maintenance and repairs = 8% on average value of $4,900	= 392
real property taxes = 1.8% on average value of $4,900	= 88
insurance = 1.5% on average value of $4,900	= 74
	$2,024

Several alternatives to the woven wire fence are available (Craven 1980, Jones and Loghurst 1958, Longhurst et al. 1962). Perhaps the most economical would be modification of existing fence. This may be done by adding 2-4 ft. in height either upright or slanted and placing strands of wire at 4-6 in intervals of 2 X 4 in. wood extensions for wooden posts or steel extensions for steel posts. These extensions may require the support of another post which would increase costs significantly. If no fence exists, either an overhanging or a slanted fence (Fig. 1) may be constructed. The advantage of these modified, or newly constructed overhanging or slanting fences is that they use less material than the 8 foot erect fence and are, therefore, less expensive. However, the slanting fence requires more maintenance. Because it works on the principle that game animals will walk under it and then be prevented from jumping over, all plant growth beneath the slant must be kept mowed. Another disadvantage of the sloping fence is that if used where there is livestock grazing, the livestock may trample the fence. These overhanging and sloping fences are primarily psychological rather than physical barriers.

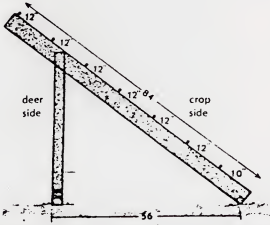

Figure 1. A slanted deer fence. It can be constructed as an electric or non-electric fence (Craven 1983).

Electric fencing, whether temporary or permanent, is also a more economical alternative to the 8 ft. woven wire fence, and several designs have been tested and are in use (Brenneman 1982; Craven 1983, 1980; Longhurst et al. 1962; Roberts 1964; Porter 1983; Schemnitz 1983, Tierson 1969). The most effective permanent design is referred to as the Pennsylvania 5-wire fence (Palmer and Wingard 1982). Figure 2 shows the design of this fence using 12.5 gauge high tensile galvanized steel wire with a high voltage low impedence energizer. Posts are placed 50-60 feet apart on flat ground or closer to keep the bottom wire 10 in. above ground. The most current version of the fence has it grounded by a 24 ft. rod or pipe buried deep enough to be in moist soil (George et al 1983). This fence was effective in preventing browsing in hardwood clearcuts (Brenneman 1982). Deer behavior makes the fence effective because they normally go through or under a fence, which in this case shocks the deer and conditions it to avoid the fence. Subordinates learn this beha-

vior then from the more dominant individuals (George et al. 1983). Costs (Table 2) compare to $6.60/ft for woven wire fence (8 ft.) and vary somewhat due to terrain, etc. Wider spacing than indicated (Fig. 2) was ineffective. The fence has low maintenance costs, and battery life averaged 43 days with marine batteries (Breneman 1982). Longhurst et al. (1962) suggested electric fences were ineffective during the dry season because of poor grounding. They suggested two rows of fence might alleviate that problem. Tierson (1969) designed and tested a 5-wire electric fence with 3 wires spaced 16 in. apart and 2 spaced 20 in. apart. He stated that costs ($22.47/acre) and the marginal efficiency prevented him from recommending it as a management tool. Problems he reported were the need to control vegetation to prevent grounding and that commercial charging equipment was ineffective. Craven (1980) stated that electric fences were less expensive to build but had higher maintenance costs than woven wire fences because of problems with deep snow, broken insulators and grounding by plants. Figure 3 shows a design he reported. Craven (1980) also includes a temporary electric fence design. Porter (1983) reports on a temporary design in which deer are attracted to make nose-fence contact, thus conditioning them to avoid the fence. The fence consists of one wire 1m above ground with flagging coated with peanut butter. Costs were $0.15/m for all materials but the energizer, construction time was 100m/man-hour, and maintenance was 8 man-hours/month to control vegetation under the fence, replace flags, and coat flags with peanut butter. An electric fence effective against pronghorn consisted of two strands of wire 8-10 in. apart 3 ft. above the ground (Schemnitz 1983).

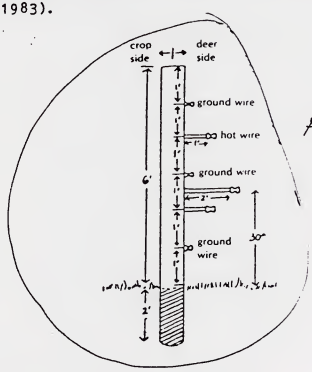

Fig. 3

Figure 2. Pennsylvania 5-wire electric fence.

Table 2. Construction costs for Pennsylvanias 5-wire deer fence (George et al. 1983)

Area (acres)	Perimeter (ft.)	Cost/acre	Cost/ft.
5	1868	$114.00	$0.31
10	2640	74.58	0.28
20	3734	47.00	0.25
50	5903	27.22	0.23
100	8348	18.18	0.22

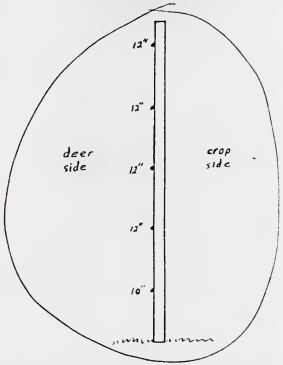

Fig. 2

Figure 3. An electric fence of traditional design (Craven 1983).

Panelling has also been used to temporarily control game damage to crops (Wilkins 1957, Marcoux 1983, T. Killough pers. comm.). MDFWP field biologists (pers. comm.) have reported using panelling on square hay bail stack yards and on round bails if panels are stacked 2 high. They also report using electric fence with limited success, although not the Pennsylvania 5-wire design, and woven wire fences. The electric fencing used has been aluminum ribbon and another ribbon tape design both available from Mountain Scent Research, Stevensville, MT.

Cultural Methods

Prevention of big game damage through cultural methods has been suggested (Craven 1983, deCalesta 1983, Howard 1964, Schemnitz 1983, Webb 1960) but has limited application and success. Big game animals may be deterred from foraging on

agricultural crops by planting of alternative more preferred forages. The period of vulnerability to game damage can be reduced by harvesting crops as early as possible. Also, planting frequently damaged crops as far as possible from cover may help prevent damage. Tall crops, such as corn, planted as a barrier between rangeland and small grain fields may help curtail damage. Howard (1964) suggested that reseeding was often more effective in stabilizing habitat than excessive expenditures on deer control. This method may be useful where damage to newly planted crops has occurred. In short, there are few cultural methods available, none of which is highly successful.

Repellents

Repellents have been used in preventing wildlife damage to crops including 1) chemical repellents, 2) scare devices, and 3) hazing. None are totally effective, but all are considered temporary measures and in that respect are very effective. Craven (1980) stated that the success of repellents must be measured in reduction of damage, not elimination. Hesselton and Hesselton (1982) suggested there was a need for further research on repellents.

The use of repellents of all types has been suggested by several researchers and managers (Anonymous 1979; Craven 1983, 1980; deCalesta 1983; Dietz and Tigner 1968; Halls 1978; Harris et al. 1983; Marcoux 1983; Palmer et al. 1983; Schemnitz 1983; Wall 1983, Webb 1960). Some chemical repellents and scare devices are already being used in Montana (Marcoux 1983). MDFWP field biologists (pers. comm.) indicate that blood meal is used extensively, primarily for standing crops with the greatest success where the blood meal is hung in gunny sacks at fence crossings. However, they also indicate that use in similar situations has differing results. Propane scare guns were also reported to have variable results, the lack of success due to habituation of deer to the guns. Steve Knapp (pers. comm.) stated that in some instances deer would be feeding next to the guns when discharged and they wouldn't flinch. Craven (1983) suggested moving the scare guns and staggering the firing sequence would maximize their effectiveness. However, S. Knapp (pers. comm.) indicated that even this did not always prove effective.

Other scare devices or frightening strategies include gunfire, fireworks, and dogs on a long run (not free-ranging), all of which have limited use (Craven 1980, Marcoux 1983, Schemnitz 1983). Hazing using a helicopter has been used on elk but is very expensive and short lasting (deCalesta 1983, Marcoux 1983).

The most effective and widely used of the repellents are chemical repellents, both contact and area. Contact repellents have limited use for Montana as very few can be used on consumed crops. Most are applied in the prevention of browsing in orchards or on seedlings in reforestation. Area repellents which are in use include fermented or synthetic fermented egg (SFE)

which research has shown to be a very effective repellent. Bullard et al. (1978) reported lab testing showed acceptance of vegetation sprayed with SFE was lower than the control and that in field conditions increased concentration increased the repellency. Harris et al. (1983) indicated putrescent egg passed a preliminary screening of deer repellents and should be further investigated. Palmer et al. (1983) indicated this repellent was the only one of those tested which differed significantly from a control in repelling deer. This fermented egg repellent has been recommended by others after effective test results and application (Craven 1983, 1980; Wall 1983).

Other repellents available that have had some reported success include ZAC (zinc dimethyldithio/carbamate, cyclohexylamine complex), thiram or TMDT (tetramethylthiurum disulfide) (Dietz and Tigner 1968). Table 3 shows additional repellents which have been tested and are successful (Anonymous 1979, Harris et al. 1983, Palmer et al. 1983). Many of the repellents in Table 3 are also applied by suspension from fences etc., in burlap sacks or netting, by scattering on the ground near the crops to be protected, or soaking rope to be strung around the crops.

Table 3. White-tailed deer repellents tested at The Pennsylvania State University Deer Research Facility, summer 1979 (Harris et al. 1983).

Trade Name	Active ingredient (%)	Application Process
Home remedies		
Feather meal	Ground chicken feathers (100)	5 g/500 g corn
Mothballs	Naphthalene (100)	3 balls (8 g)/500 g corn
Creosote	Creosote (97)	saturated 25-cm^2 rag/500 g corn
Hot sauce	Capsaicin (2.5)	spray coverage (0.0012% active ingredient)
Hair	Human hair clippings (100)	2 g/500 g corn
Blood meal	Blood (100)	10 g/500 g corn
Meat meal	Tankage (100)	10 g/500 g corn
Registered (EPA) deer repellents		
Big Game Repellant	Putrescent egg solids (37)	spray coverage (0.4.93% active ingredient)
Magic Circle	Bone tar oil (93.8)	saturated 25-cm^2 rag/500 g corn
Spotrete-F Flowable Fungicide	Thiram (42)	spray coverage (5.25% active ingredient)
Hinder	Ammonium soaps of higher fatty acids (15)	spray coverage (0.71% active ingredient)
Gustafson 42-S	Thiram (42)	spray coverage (2% active ingredient)
Chaperone	Thiram (7)	spray coverage (7% active ingredient)
Nott Chew-Not	Thiram (20)	spray coverage (10% active ingredient)

The major difficulty with chemical repellents is weathering (Bullard et al. 1978, Craven 1980, Palmer et al 1983, Wall 1983). They must be applied repeatedly because of evaporation, dissipation by rain, or they simply wear out. George et al. 1983, Halls 1978, and Longhurst et al. 1962, state that repellents are expensive and ineffective in comparison to more permanent remedies. However, managers must remember that the use of repellents is only a temporary measure. Halls (1978) further suggested that repellents may simply force deer into other areas, in which case careful judgement should be used in determining whether to use

repellents. Palmer et al. (1983) stated that repellants which may be effective in one situation may not be in another.

Attractants

Dasmann et al. (1967) discussed the use of attractants as one approach to controlling the deer damage problem. They suggested using attractants such as molasses to increase the palatability of non-crop plants, using highly preferred deer plant foods to attract deer as well as supplemental feeding using hay, pellets, felled trees, etc. Webb (1960) suggested establishing areas devoted to production of game foods and using winter feeding to prevent damage. Hubert et al. (1980) also recommended using supplemental feeding. Baits for deer trapping tested by Howard et al (1974) and Mattfeld et al. (1972) may also be useful as attractants. However, the potential problems associated with attractants, especially supplemental feeding, put them at a disadvantage in comparison to other temporary damage control measures. Attractants may lure game that otherwise might not be in an area. They may also increase the carrying capacity of an area which would create additional problems if game harvests were not adequate.

Removal

Live trapping and removal of elk in Montana has been used to control crop damage (Marcoux 1983). Craven (1983, 1980) and Schemnitz (1983) also suggested using trapping and removal to control deer and pronghorn damage. However, Craven (1980) stated that this was rarely practical at a cost of over $100/deer. Considering that costs are now higher than reported by Craven (1980), this method should probably only be used as a stop-gap last-resort measure.

Compensation

McDowell and Pillsbury (1959) reported 10 states paying compensation to landowners for crop damage caused by game. The fact that this practice does nothing to control or prevent damage may in fact lead to increased damage through non-action, and is very costly, makes it a very poor practice. Harder (1968) reported that damage claims present a grave financial problem. Roberts (1964) stated:

> All state wildlife agencies are unanimous in their agreement that this approach (compensation) constitutes financial strangulation and does not solve damage problems.

deCalesta (1983) reported that compensation may be temporarily satisfactory to ranchers and farmers, but does nothing to alter circumstances favoring damage, and may even cause it to increase.

RECOMMENDATIONS

Population control through sport hunting, from the wildlife agencies' perspective, is the most attractive and inexpensive and therefore, the best method of controlling game damage. At the very least, population control is necessary before alternate methods can be expected to succeed.

Alternate methods may be temporary or permanent. Of these attractants, removal, and compensation cannot be recommended either because of prohibitive expense or because of the potential for confounding the damage problem or creating more serious problems. All of the remaining control measures (exclusion, cultural methods, repellents) have temporary application. Only exclusion can provide a permanent solution.

Fencing is an expensive solution but is the most effective. Before a decision to use permanent fencing can be made, an analysis of the cost/benefit ratio of such a fence will make it more practical. Permanent fencing using an 8 ft. woven wire construction should be used only for stackyards or for standing crops where game pressure is heavy or the crop has a high market value. This fence design is not necessary for protection from pronghorn. Two less expensive designs which would provide protection from both deer and pronghorn are the slanted fence and the Pennsylvania 5-wire electric fence. However, both would require more maintenance than the woven wire fence. These designs might make permanent protection of standing crops more economically feasible. Temporary electric wire or ribbon, or baited electric fences around stackyards or standing crops during periods of potential damage would be more economical in the short term so would be the use of panelling for stackyards.

Scare devices in any situation are not recommended unless the duration of the problem is expected to be very short. Game become habituated to scare devices in a very short time.

Bailed crops left scattered in the field are best protected by temporary use of chemical repellents. In fact, chemical repellents, either home remedies or registered, are probably the most feasible temporary control measures that can be used for scattered bails, stackyards, or standing crops. They have application either in short term damage situations or as temporary control before implementing permanent measures. The most highly recommended repellent, based on prior testing, is fermented egg, either natural or synthetic and marketed under several names. Timm (1983) provides a directory of manufacturers, formulators, and suppliers of wildlife damage control products.

Finally, cultural methods such as planting buffer crops, tall crops as barriers between rangeland and production crops, harvesting as early as possible, and planting as far from cover as possible are measures which may be more economically feasible than fencing or more effective than repellents.

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